Gulf of Mexico Science, 2004(1), pp. 54–61

Immature Sea Turtles in Gullivan Bay, Ten Thousand Islands, Southwest Florida

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An in-water survey for immature endangered and threatened sea turtles in the coastal waters of southwest Florida during 1997–2003 yielded 191 Kemp's ridley (*Lepidochelys kempi*), 15 loggerhead (*Caretta caretta*), 13 green (*Chelonia mydas*), and one hybrid hawksbill (*Eretmochelys imbricata*)-loggerhead turtle. Mean carapace lengths were 40.3 cm minimum straightline carapace length (MSCL) for Kemp's ridley, 65.5 cm MSCL for loggerhead, and 51.6 cm MSCL for green turtles. Fibropapilloma tumors were found on seven of the green turtles and one loggerhead turtle. The mean growth rate of recaptured Kemp's ridleys was 6.3 cm/yr. The nearshore waters of Gullivan Bay in the Ten Thousand Islands are an important developmental habitat for the highly endangered Kemp's ridley turtle, and to a lesser degree, immature loggerhead and green turtles.

The U.S. Endangered Species Act of 1973 lists sea turtles as either endangered or threatened in U.S. waters. The decline of these turtle populations has been attributed to several factors, the most important being direct harvesting, incidental takes in commercial fishing activities, pollution, and habitat loss (National Research Council, 1990). Recovery plans have been developed for each turtle species that delineates goals and strategies necessary to recover the depleted turtle populations.

Neonate sea turtles leave their natal beaches and spend several years in the pelagic environment feeding on planktonic organisms associated with floating *Sargassum* weed (Musick and Limpus, 1997). These juvenile turtles leave the pelagic environment after a few years and settle in shallow coastal habitats where they feed on benthic invertebrates, grasses, and algae. These coastal developmental habitats may be hundreds of kilometers from their natal beaches. Turtles eventually leave these coastal habitats with the onset of maturity and migrate back to their natal beaches to reproduce (Musick and Limpus, 1997).

Marine resource managers need to identify coastal developmental habitats and gather ecological information to formulate recovery strategies under the existing recovery plans. Several studies on immature sea turtles in coastal habitats have been conducted in the western and central Gulf of Mexico. Shaver (1994) published information on the seasonality and growth of immature green turtles (*Chelonia mydas*) in south Texas, and netting surveys conducted by Werner (1994) and Coyne (2000) provided information on the feeding habits and sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempi*) on the Texas–Louisiana border. The status of sea turtle stocks, movements, and general overview of sea turtles in the northwestern Gulf of Mexico is provided by Landry and Costa (1999). Rudloe et al. (1991) reported information on the sizes and associated habitats of immature ridleys from Apalachicola, Florida, and Schmid (1998, 2003) reported information on sizes, growth, and habitat usage of immature ridleys from the Cedar Keys, also in northwestern Florida.

The coastal region of southwest Florida, from Marco Island south to Florida Bay, has numerous undeveloped mangrove islands (collectively called the Ten Thousand Islands) that had not been previously surveyed for immature sea turtles. Information concerning the distribution and abundance of sea turtles in southwest Florida is limited to nesting surveys (Meylan et al., 1995; Foley et al., 2000; Garmestani et al., 2000) and stranding reports (FDEP/FMRI, 1998). Consequently, habitat use and the population status of immature turtles in these nearshore Gulf waters are unknown.

Identifying developmental habitats is important to sea turtle management, but it is of particular importance for the Kemp's ridley turtle because of its highly endangered status. Kemp's ridleys nest primarily at Rancho Nuevo, Tamaulipas, Mexico, in the western Gulf of Mexico (Fig. 1). Hatchlings leave the nesting beach and spend 1–3 yr in the pelagic Gulf and northwest Atlantic waters (Collard and Ogren, 1990). Postpelagic turtles recruit to coastal-benthic habitats after 1–2 yr (20–25 cm), where they continue to develop for another 8–9 yr until maturing at approximately 60 cm (Schmid and Witzell, 1997; Schmid, 1998). Adult turtles occupy benthic habitats further

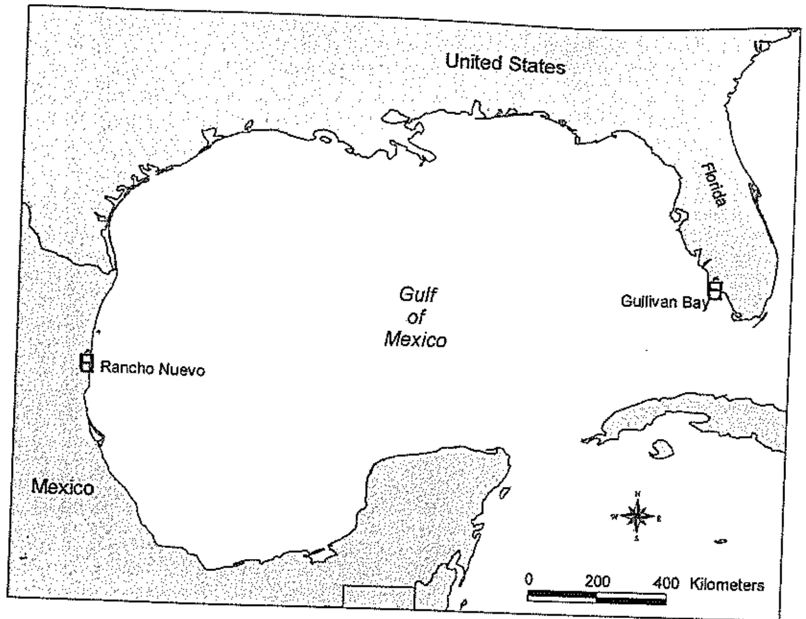

Fig. 1. Map of Gulf of Mexico showing the location of Gullivan Bay study area and main nesting site of Kemp's ridley turtles at Rancho Nuevo, Tamaulipas, Mexico.

offshore in the northern and southern Gulf (National Research Council, 1990). Developmental habitats also occur on the U.S. Atlantic coast, from summer foraging grounds in Cape Cod Bay, MA (Lazell, 1980) and Long Island Sound, NY (Burke et al., 1991, 1994; Morreale and Standora, 1998), southward to overwintering areas off Cape Canaveral, FL (Henwood and Ogren, 1987; Schmid, 1995).

Kemp's ridley turtles from the eastern U.S. were once believed to be lost to the Mexican reproductive population, but tagging data indicate that they reenter the Gulf of Mexico on maturity and nest at Rancho Nuevo (Witzell, 1998). Known major Kemp's ridley developmental habitats are located in the Gulf of Mexico near the Texas–Louisiana border (Werner, 1994; Landry and Costa, 1999; Coyne, 2000), Apalachicola, FL (Rudloe et al., 1991) and the Cedar Keys, FL (Schmid, 1998). Here we analyze National Marine Fisheries Service tagging data collected in the Ten Thousand Islands, Florida from 1997 to 2003 to determine species composition, relative abundance, and size frequency of immature sea turtles. Additional information on the growth of Kemp's ridley turtles is provided.

Materials and Methods

The turtle survey was conducted in Gullivan Bay, located in the Ten Thousand Islands on the southwest coast of Florida (Fig. 2). In-water sampling was concentrated in the eastern portion of the bay, primarily at Gullivan Key (between Turtle Key and Whitehorse Key). The U.S. Fish and Wildlife Service Ten Thousand Islands National Wildlife Refuge and the Florida Department of Environmental Protection Rookery Bay National Estuarine Research Reserve jointly manage this area. The area is characterized as an undeveloped estuarine system with numerous bays, lagoons, and tidal streams (USFWS, 1999). It has a mean depth of 3 m and a tidal range averaging 0.6 m, with higher and lower extremes during spring tides. Salinities range from 18.5 to 39.4‰, depending on seasonal rainfall. The water is turbid, and visibility ranges from 30 to 95 cm. There are numerous mangrove islands throughout the area. The sea bottom habitat is diverse, ranging from shallow soft mudflats and oyster reefs in the backcountry to sandy shoals with sparse submerged vegetation and deeper shell-rock channels with small, isolated hard-bottom communities (tunicates, sponges, bryozoans, and gorgonians) on the Gulf side of the barrier islands.

Visual surveys were initiated in June 1997. The general survey area was originally selected after we interviewed several commercial fishermen for an area likely to have turtles. The vessel was stopped in the survey area at a site, and we looked for the heads of turtles surfacing to breathe. The selection of a particular

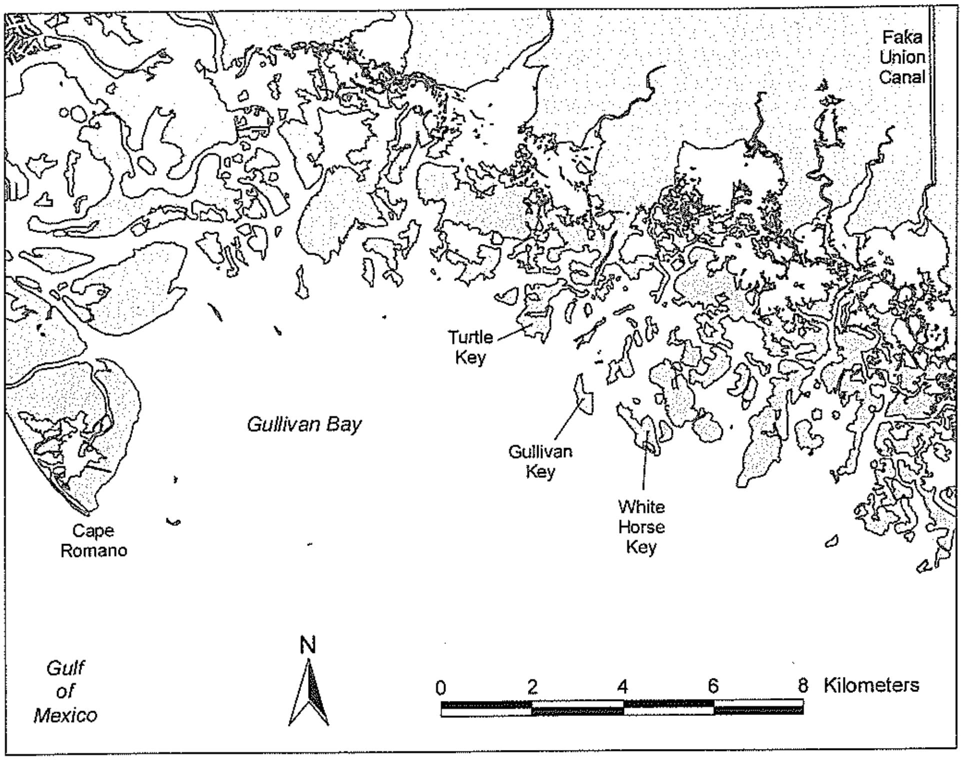

Fig. 2. Map of main study area in Gullivan Bay.

site was determined by the tide, wind speed and direction, and sea state. If no turtles were sighted after several hours, we moved to a new site within the general area. Turtle species were identified by head shape, size, and color and noted in the field log (date–time–location). Netting surveys were initiated in July 1997 and were conducted for 3–4 consecutive d each month through June 1999. No turtles were seen during the cold months of Jan.–March 1998 when water temperatures dropped below 20 C, although we did see turtles during those months in subsequent, warmer, years. In July 1999, the in-water sampling schedule was increased to two 5-d surveys each month through Sept. and reduced to 1 wk each month from Oct. through Dec. 1999 and terminated in Jan.–March when exceptionally cold water temperatures (<20 C) would drive the turtles from the in-shore waters. Biweekly netting surveys were conducted from April to Nov. during 2000–2001, with no netting effort during the winter months (Jan.–March) of each year. Research efforts shifted from netting surveys to telemetric monitoring during 2002 and 2003, and tag data collected on these turtles were included in the analyses.

The conventional set entanglement net used by other Gulf of Mexico sea turtle projects (e.g., Werner, 1994; Schmid, 1998; Coyne, 2000) would be difficult to fish in the Ten Thousand Islands without adversely affecting the numerous marine mammals (manatees and dolphins) or capturing sharks and stingrays. The strike-net technique we used reduced unwanted by-catch by minimizing the time the net stayed in the water. Consequently, estimating a catch-per-unit-effort (CPUE) index was not practical. A 20.5-cm stretched-mesh nylon strike net was fished from a 6-m commercial boat to capture turtles that surfaced near the vessel. The net was deployed off the stern at high speed, encircling the turtle, and held closed until the turtle was either observed entangled in the net or until 20 min had elapsed without sighting the animal. The net was immediately hauled in, regardless of the success of the turtle capture, if marine mammals were seen in the immediate vicinity. Capture success varied with weather conditions (wind and sea state), tidal strength, distance from a sighted turtle, alertness of the turtle, and amount of time a turtle spent at the surface. Many turtles were too far from the vessel to strike or did not remain on the surface long enough to confidently obtain a strike location. It is estimated that the overall capture success of struck turtles ranged between 60% and 80%. Each capture location was recorded using a handheld global positioning system. Attempts were made to capture all immature turtles encountered. Only the large adult loggerheads (*Caretta caretta*) that were occasionally observed in the study area were avoided because they were too large and aggressive to safely land in the boat for data collection.

The following morphometric measurements were recorded for each turtle: total straightline carapace length (anterior most edge of carapace to posterior margin of supracaudal scutes), standard straightline carapace length (SSCL, midline of nuchal scute to posterior margin of supracaudals), minimum straightline carapace length (MSCL, midline of nuchal scute to the posterior notch of supracaudals), minimum curved carapace length (midline of nuchal scute to the posterior notch of supracaudals), and straightline carapace width at the widest point. Minimum straightline carapace length was used in data analyses because the posterior margins of the supracaudals were prone to damage. Straightline lengths and width were measured to the nearest 0.1 cm with Vernier calipers. Curved carapace length was measured to the nearest 0.1 cm with flexible fiberglass tape. Carapace measurements were made by one of us and recorded by the other to avoid individual differences in measurement technique. Weight was measured to the nearest 0.25 pounds with a spring scale and converted to kilograms. Notes on the condition of the turtle were recorded if the animal was injured or deformed (tag scars, carapace and flipper wounds, fibropapillomas, etc.).

Turtles were double tagged from July 1997 to Oct. 2001, and single tagged thereafter, on the trailing edge of the front flippers with no. 681 Inconel cattle ear tags. In addition, passive integrated transponder (PIT) tags were placed in the left front flipper of Kemp's ridley turtles. During 1999 and 2000, blood samples were collected for sex determination, and selected turtles were held in shaded 1.5- to 2-m-diameter tanks for 24–48 hr to collect fecal samples for food analysis. Tissue samples were taken from green and loggerhead turtles for genetic analysis to determine natal origin. The results of blood and fecal analyses will be reported elsewhere, and tissue samples were archived. All turtles not held for fecal analysis were processed immediately and released near the original capture site.

Yearly growth rates for Kemp's ridley turtles were estimated with the following formula:

$$G = \frac{\Delta \text{Length}}{\text{Days}} \times 365$$

where G is the growth rate in cm/yr, Δ is the difference between initial and recapture carapace length, and Days is the number of days at large from initial capture.

Growth rates were pooled and generated in terms of recapture interval duration, recaptures between vs recaptures within netting seasons, and size classes of recaptured turtles. Growth rates were assigned to 10-cm size classes based on the mean of the initial and recapture carapace measurements. Means are accompanied by ±1 SD.

Results and Discussion

Sea turtles were collected or sighted in the nearshore waters of Gullivan Bay during all months of the year; however, their abundance typically decreased in the winter months (Dec.–Feb.), and turtles were not observed during some of the colder months (e.g., Jan.–March, 1998). Immature Kemp's ridley turtles were the most abundant sea turtle species encountered, with most captures–observations occurring between Turtle and Whitehorse keys (Fig. 2). A total of 191 immature Kemp's ridleys were captured during the survey, and an additional 45 recaptures were recorded for 30 of these turtles. One adult-sized turtle (65.2 cm MSCL) that exhibited a tag scar on the left front flipper was also captured; however, a PIT tag was not detected and there was no sign of a living tag in the carapace to indicate the origin of the tag scar. Kemp's ridley turtles ranged from 21.4 to 65.2 cm MSCL (mean = 40.4 ± 6.7 cm; Fig. 3) with a mean weight of 10.3 (±4.5) kg. Several small turtles (≤30 cm) were not captured because the large mesh net allowed them to escape. Kemp's ridleys captured in Gullivan Bay were slightly smaller than the ridleys captured by entanglement nets at the Cedar Keys (mean = 44.5 cm SSCL; Schmid, 1998) but were similar to those from the Texas–Louisiana border (mean = 40.0 cm SCL; Coyne, 2000). The mean length of Gullivan Bay ridleys was larger than the 36.7 cm mean SCL reported by Rudloe et al. (1991) from turtles incidentally caught in shrimp trawls at Apalachicola, FL. However, these size comparisons are confounded by differences in sampling gear and measuring techniques used in each study.

Twenty-eight Kemp's ridley turtles were recaptured a total of 38 times, yielding 38 annual growth rates. Three turtles had multiple recap-

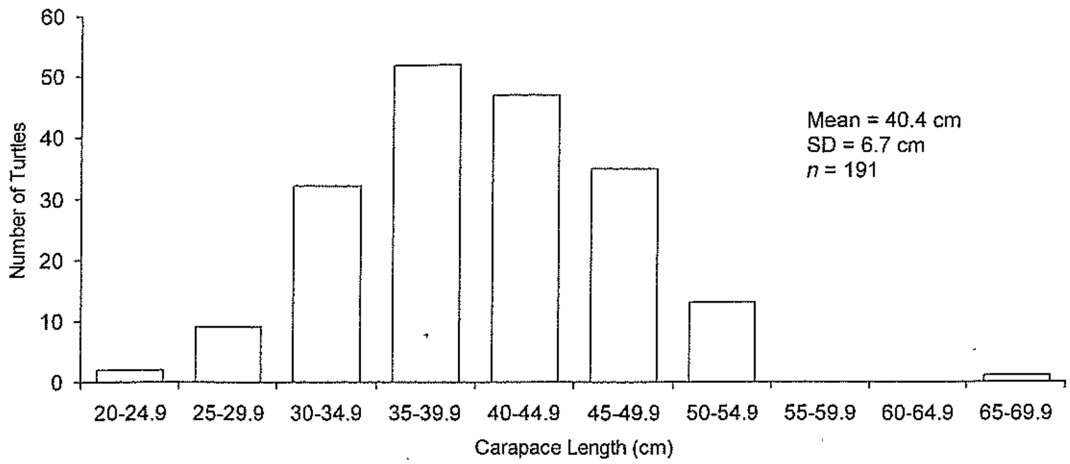

Fig. 3. Length–frequency of Kemp's ridley turtles captured in Gullivan Bay.

tures between netting seasons for up to 2 yr, and five turtles had multiple recaptures both between and within seasons. There was little variation in growth rates among the recapture intervals and between the netting season data treatments (Table 1). However, mean growth rates among size classes indicate that turtles in the 20- to 29.9-cm and 30- to 39.9-cm size classes grow much faster (8.5 and 8.0 cm/yr, respectively) than the 40- to 50-cm turtles (5.6 cm/yr). The mean growth rate for turtles <40 cm (8.0 ± 3.0 cm/yr; n = 15) was significantly greater (t = 2.71; $P = 0.005$) than that of turtles >40 cm (5.6 ± 2.6 cm/yr; n = 23). This difference in growth rates may be due to an ontogenetic change in growth for immature Kemp's ridley turtles in coastal-benthic habitats resulting from a change in diet or the onset of maturation. Increased levels of plasma testosterone were reported for predicted male turtles >37 cm MSCL in the Cedar Keys, prompting Gregory and Schmid (2001) to suggest that gonadal maturation began at this size class. Despite differences in measuring techniques, the overall mean growth rate from Gullivan Bay (6.5 cm/yr) was slightly higher than the 5.4 cm/yr reported from Cedar Key (Schmid, 1998). This difference may reflect a longer growth season in the Ten Thousand Islands, and these turtles may not migrate as far, if at all, from their southern foraging habitat during winter.

TABLE 1. Mean annual growth rates (cm/yr) for Kemp's ridley turtles captured in Gullivan Bay by (a) recapture interval, (b) netting season, and (c) size class. The SD is given in parentheses. Turtles were assigned to size classes on the basis of the mean of initial and recapture MSCL.

Data treatments	n	Mean MSCL growth rate	Range of growth rates
(a) Recapture interval			
All recaptures	38	6.5 (3.0)	1.4–12.2
Recaptures > 90 d	25	6.5 (2.9)	1.6–12.2
Recaptures > 180 d	17	6.4 (2.8)	2.7–12.2
(b) Netting season			
Within season	17	6.5 (2.9)	1.4–11.3
Between seasons	21	6.6 (3.1)	1.6–12.2
(c) Size class			
20.0–29.9 cm	2	8.5 (1.8)	7.2–9.7
30.0–39.9 cm	13	8.0 (3.2)	1.8–12.2
40.0–49.9 cm	22	5.6 (2.7)	1.4–11.3
50.0–59.9 cm	1	5.5	

Loggerheads comprised the second most abundant sea turtle species observed–captured during the survey. Two large loggerheads were unintentionally captured while setting for ridleys, both of which were identified as males by their long tails, and both were released without processing. A third male loggerhead was captured and brought aboard for data collection (73.6 cm MSCL; 14.5 cm tail length from plastron to tip of tail). There were 15 loggerhead captures, including the three males, and an additional three recaptures. Two of the recaptured turtles had been originally tagged in Gullivan Bay and had been at large for 411 and 926 d. The third recapture was an immature turtle that was missing a front flipper. The turtle had been rehabilitated in Key West and released 2 yr before recapture. The turtle appeared robust and healthy, despite having incurred carapace damage from a possible boat

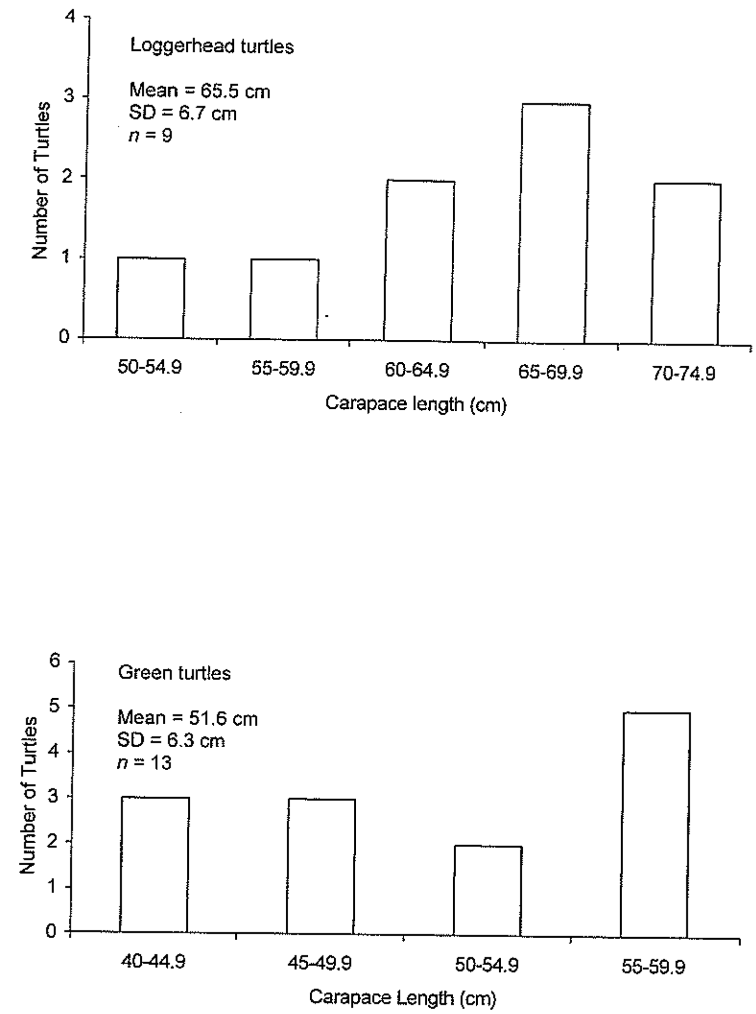

Fig. 4. Length–frequency of loggerhead and green turtles captured in Gullivan Bay.

collision after release. Another immature turtle had numerous fibropapilloma tumors on the head and neck, a condition most commonly associated with green turtles (Lackovich et al., 1999). The mean carapace length of the measured turtles was 65.5 cm MSCL (Fig. 4) and was similar in size to the loggerheads from the Cedar Keys (mean = 65.0 cm SSCL; Schmid, 1998). A similar protocol for releasing large turtles was also used in the Cedar Keys study.

Green turtles were the least abundant species captured–observed during the survey. They were frequently found near areas of sparse seagrass. A total of 13 green turtles were captured, one of which was recaptured 2 d later at the same location. Seven of the green turtles exhibited fibropapilloma tumors. Green turtles had a mean carapace length of 51.6 (±3.4) cm MSCL (Fig. 4) and a mean weight of 23.1 (±7.9) kg. The Gullivan Bay turtles were similar in size to green turtles captured from the Cedar Keys (mean = 56.8 cm SSCL; Schmid, 1998) but were substantially larger than the green turtles reported from south Texas coastal waters (mean = 34.2 cm SSCL; Shaver, 1994). The observed difference is unknown but may result from ontogenetic shifts in habitat use by immature green turtles. Data from netting studies on the southeast coast of Florida indicate that smaller size classes of green turtles are captured on nearshore reef tracts, whereas larger sizes are collected from lagoonal seagrass beds (Schmid, 1995). Green turtles from south Texas were collected near rock jetties, where the use of this habitat was documented with telemetric methods (Renaud et al., 1995), whereas green turtles on the west coast of Florida were primarily captured on or near seagrass beds. Genetic analyses were recently conducted in east-central Florida (Bass and Witzell, 2000), and similar studies are needed to determine the demographics of green turtles in Gulf of Mexico foraging habitats.

A turtle originally identified as a hawksbill (*Eretmochelys imbricata*), based on its morphological characteristics, was also captured during the survey. Subsequent genetic analyses revealed that the turtle was a hybrid hawksbill-loggerhead turtle (Witzell and Schmid, 2003). The hybrid was recaptured four times in the same area off Whitehorse Key for a period of 690 d and grew from 54.2 to 64.6 cm MSCL during this period.

Conclusions

The large number of immature sea turtles captured–observed during this study suggests that Gullivan Bay is an important developmental habitat, especially for immature Kemp's ridley turtles. There are two other coastal developmental areas documented for Kemp's ridleys in the Gulf of Mexico: the Texas–Louisiana border (Werner, 1994; Landry and Costa, 1999; Coyne, 2000) and Cedar Key, FL (Schmid, 1998). The Gullivan Bay habitat appears to support a population of immature ridleys comparable with the populations in Texas–Louisiana and Cedar Key, although a direct comparison of CPUE is impossible. Recaptures within a netting season indicate that some Kemp's ridley turtles remain in the nearshore waters of Gullivan Bay for several months, and recaptures between seasons indicate that turtles return to this foraging area for up to 3 yr. However, the low recapture rate suggests that many Kemp's ridleys may move either south to the Everglades National Park, an area ecologically indistinguishable from the Gullivan Bay study area. The coastal area of southwest Florida (Gullivan Bay to Florida Bay) could be the major developmental habitat for immature Kemp's ridleys if concentrations of turtles throughout the rest of the Ten Thousand Islands are comparable with Gullivan Bay. Surveys are needed from Gullivan Bay south to Florida Bay to confirm the presence or absence of immature ridleys throughout southwest Florida coastal waters.

Gullivan Bay is used to a much lesser extent by immature and mature loggerhead turtles. These turtles may prefer deeper waters offshore, where commercial stone crab fishermen often encounter them near their traps, and recreational hook-and-line fishermen observe them near hard-bottom areas (M. Finn, pers. comm.). Even fewer green turtles were encountered during this survey. This is probably attributable to the sparse seagrass habitats in eastern Gullivan Bay because of the more turbid waters. Green turtles are more likely to be encountered on the extensive seagrass beds near Cape Romano, in the northwestern part of the Bay.

Eastern Gullivan Bay is an undeveloped mangrove estuarine habitat. However, these waters support a large recreational hook-and-line fishery that appears to be increasing each year. Boats from Marco Island, Naples, Everglades City, and Chokoloskee use the Bay and backcountry waters year-round with a seasonal increase in activity during winter months. Turtle–fisherman interactions do occur because there are reports of loggerhead turtles consuming recreationally fished hooks and also damaging commercial stone crab traps further offshore (M. Finn, pers. comm.). Kemp's ridley turtles exhibiting wounds from boat strikes were relatively uncommon, with only three obvious specimens observed out of 178 captures. One injured Kemp's ridley turtle had a series of deep lacerations to the posterior carapace caused by a recent encounter with a boat propeller. This individual was later recaptured with the wounds healing and a healthy appearance. Also, the hybrid hawksbill-loggerhead turtle exhibited a wound on the scales of the head, possibly form boat collision, which had healed on subsequent recapture the next year. Increasing vessel traffic in the area (fishing boats, jet skis, airboat tours, etc.) may eventually have a greater impact on the immature sea turtles in this important developmental habitat. However, efforts to minimize manatee–boat interactions might benefit sea turtles in these nearshore waters.

Acknowledgments

We are indebted to M. Finn for sharing his knowledge of the study area, for providing logistical support, and for assisting in fieldwork operations. We also thank J. and D. Bolding for providing logistical support. M. Bresette, T. Henwood, K. Mullin, and two anonymous reviewers provided useful comments on the manuscript.

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